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GEOLOGY

— OF —

Knox County, Ohio,

— BY —

M. C. READ, HUDSON, OHIO,

— FROM —

ADVANCE SHEETS OF THE

GEOLOGICAL REPORT OF THE OHIO STATE SURVEY,

1877.

PETROLEUM, AND THE KOKOSING OIL COMPANY

DIAMOND BLACK.

APRIL, 1878.

MOUNT VERNON, OHIO.
"REPUBLICAN" STEAM BOOK AND JOB PRINTING HOUSE.
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~~V. 263~~
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1878, Jan. 23.
Gratis

Please correct the Report before reading it.

ERRATA

In the following print of the "Geology of Knox County, Ohio, by M. C. Read":

Page 1... 9th line from bottom, for "space" read spur.
" 1... 3d " " " "northward" read southward.
" 2 ..11th " top " "north" read south.
" 2...13th " " " "northward" read southward.
" 4...11th " bottom " "irregular" read angular.
" 4...10th " " " "pigments" read fragments.
" 6... 3d " top " "northward" read southward.
" 7... 2d " bottom " "elevation" read relations.
" 9... 3d " " " "where" read when.
" 13... 7th " " " "curved" read caused.
" 13 ..10th " " " "covered" read caused.
" 13...bottom line between "here" and "in" insert as.
" 14...11th line from bottom, for "Folb's" read Fobes'.
" 15...top line, after "it" insert is.
" 15... 9th line from top for "limestone" read sandstone.
" 16...10th " " " "Bedford" read Cleveland.
" 16...18th " bottom " "advance" read absence.
" 20...13th " " " "well has" read wells have.
" 20...11th " " " "eighty" read forty.
" 21... 2d " top " "well" read wells.
" 21... 8th " " " "Genoa" read Gann.
" 21...19th " " " "Genoa" read Gann.
" 22... 8th " " " "eighty-eight" read eight.
" 22...13th " " " "Hard" read Hurd.
" 22...22d " " " "covered" read caused.
" 22... 2d " bottom " "as" read gas.
"Owl Creek" is the common name for the Kokosing River.

NOTE.

The annoying typographical errors in this report are explained by the unfortunate fact, that the proof was not submitted to the author, or to President Orton, to whom the proof-reading of the volume was entrusted. The other chapters are as free from errors as could be expected in any case where the proofs are not read by the author.

M. C. READ,
Hudson, Ohio.

APRIL, 1878.

GEOLOGY OF KNOX COUNTY.

BY M. C. READ.

LOCATION AND TOPOGRAPHY.

Knox county, situated directly south of Richland, is a continuation of the southern slope of the table land which separates the waters of Lake Erie from those of the Ohio River. Its surface presents a succession of hills, in part rugged and steep where influenced by the Coal Measure rocks and the Waverly Conglomerate; in part symmetrically rounded, and of very graceful outlines, where composed of the olive shales of the Waverly. These hills are all intersected by narrow ravines in which flow the tributaries of the larger streams, the latter uniformly occupying ancient valleys of erosion, and bordered by rich alluvial plains. This ancient river system of the county is very accurately defined. The main channel, commencing in the north-west corner of the county, is occupied by the head waters of Owl Creek, and is everywhere filled with coarse water-washed gravel capped with a thick deposit of alluvial soil The stream follows the line of this old channel, occasionally cutting through headlands which formerly projected into it. At Frederick, for a short distance it has a rock bottom, where a spur of the hills, extending out from the east side, is crossed by it, the old channel being easily traced a little to the west. An exposure of the rock here shows that it is much harder and more massive than usual, and had greater power of resisting erosion.

After the valley was filled up by the Drift, the modern stream found a shorter course across this space, and has cut its recent channel through the rock. This old channel extends to Mt. Vernon, where it divides, one branch continuing southward, and the other turning almost directly east, affording a fine illustration of the manner in which the topography of the country, before the Drift epoch, has controlled the course of modern streams, and in many places the location of our railroads. The engineers of the Valley Railway, running northward from Cleveland, have traced out such an old pre-glacial valley, and cross the divide in the swamp that marks its highest elevation in the north-eastern part of

Summit county. A similar channel, passing diagonally through Ashland county, having Savannah Lake as its Summit, invites the attention of railroad engineers. In Richland county, all the railroads for the greater part of their course follow the ancient valleys. In Knox county, Owl Creek and the Sandusky branch of the Baltimore and Ohio Railroad occupy the channel to Mt. Vernon, where the stream takes the eastern branch of the pre glacial valley to Coshocton county, and the railroad the southern branch into Licking county. For a part of the distance below Mt. Vernon and Gambier, the stream has made for itself an independent channel through rock spurs projecting from the north, but the course of the old river can easily be traced a little to the north of it. At Gambier it is in the ancient bed which here divided a channel extending northward toward Martinsburg, now filled with gravel and sand hills, and occupied by Big Run, which flows northward, a direction opposite to that of the old stream, and becomes a tributary to Owl Creek. At Millwood, also, the channel of Owl Creek is narrow, rock-bound, and recent, but the old channel is easily traced to the south of the massive bluffs of the Waverly Conglomerate, where it is now filled with modified Drift hills of gravel and sand.

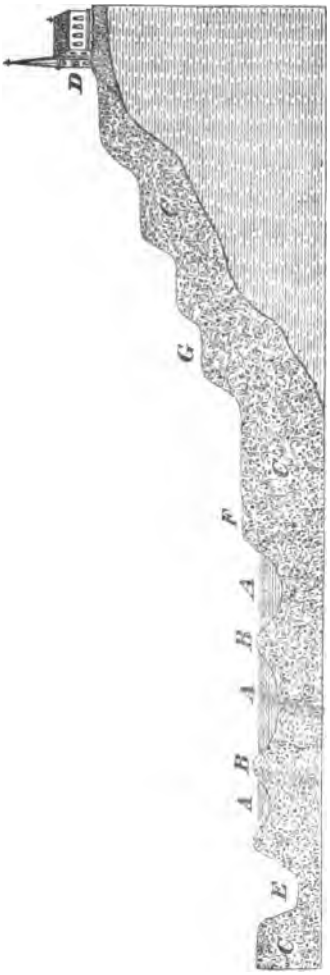
Coming down from the divide between the waters of Owl Creek and the Killbuck, the engineers who surveyed the route of the Cleveland, Mt. Vernon and Coshocton Railroad, and who had followed one of these old channels most of the way from Akron to Oxford, turned into this ancient valley, finding a level surface, no rock cuts, easy material to excavate, and abundance of gravel.

A railroad from Mt. Vernon to Coshocton could be built only by following this old pre-glacial channel.

These old valleys have been filled by glacial Drift to the summit of the adjacent hills, and probably nearly if not quite to the top of the highest hills in the county; the immense erosion which accompanied the retreat of the glacier sweeping away the great bulk of the Drift, taking all the finer materials, and leaving a residuum of sand and gravel.

The following section from Zion's church east of Gambier, to the bed of Owl Creek, indicates very clearly a chapter of this old history.

DRIFT IN OWL CREEK VALLEY.



AAA. Alluvium of river bottom.

BB. Ridges of gravel rising above the alluvium.

CCCCC. Drift gravel.

D. Zion's church on a sand-hill with a core of Waverly rock.

E. Channel of river in gravel.

F. Terrace of ten feet.

G. Terrace of thirty feet, the elevation from G to D being ninety five feet.

Wells drilled for oil on the borders of this stream toward the Coshocton line show that this deposit of coarse gravel extends at least eighty-two feet below the bottom of the valley, and in one instance a log was struck at a depth of one hundred feet. Hence there is here disclosed a broad valley once filled with Drift to the depth of not less than two hundred and seventeen feet, through which a channel has been plowed one hundred and thirty-five feet, in depth, leaving a succession of terraces, the stream now flowing nearly one hundred feet above the bottom of the old gorge. Observations to be noted hereafter indicate even a much greater thickness of this deposit elsewhere.

A section across the stream from Mt. Vernon west, gives a much broader alluvial plain, a similar succession of terraces rising gradually to land covered with unmodified clay Drift, containing striated boulders.

The hills east of Mt. Vernon are generally covered with Drift containing abundant debris of Waverly, and many granitic boulders. Patches of typical clay Drift are most abundant on the slopes near the top of the hills, and in places exposed ten feet thick.

Following the Columbus road westward toward Mt. Liberty, the surface rises very slowly from the river over a bed of fine gravelly and sandy alluvium, filled with small bowlders, many of them of limestone, then striking irregular drift-hills which reach an elevation one hundred and fifty-five feet above the railroad at Mt. Vernon. The material of these hills is coarse, consisting chiefly of gravel and sand, with flat fragments from the Waverly, and a few large granitic bowlders. The surface is irregular and billowy, as if piled up by the action of shore waves when the water stood at this elevation. Thence to Mt. Liberty the surface rises to the height of two hundred and twenty-five feet above the railroad, the wagon road passing over undulating Drift hills, the materials steadily becoming coarser, containing more limestone, and more flat fragments of rock. The underlying strata are entirely covered by this deposit. Wells on the hills at Mt. Liberty show,

		FEET.
1.	Gravel	15
2.	Blue clay	5 to 15

when quicksand, resting upon shelly sandstone, is reached, and affords an abundant supply of water.

West of Mt. Liberty a cut on the railroad at an elevation of two hundred and eighty-five feet above the depot at Mt. Vernon shows that the Drift is wholly unstratified. It contains a large percentage of small limestone bowlders. Many of these are striated, but none of them rolled or water-worn. Finely broken, irregular fragments are abundant, and a moderate quantity of flat and broken pigments of the Waverly are seen. This is typical unmodified glacial Drift, and this deep gorge was filled with it to the height of at least two hundred and eighty-five feet above the present bed of the stream. Similar deposits yet remaining in protected places on the level of the stream show what was the original material which filled the valley.

In Hilliar township the hills are composed of tenacious clay Drift, the wells showing eight to eighteen feet of yellow clay, then blue clay passing into hard-pan on the hills and resting on quicksand in the valleys. On the bottom lands of the stream we find—

		FEET.
1.	Soil, black loam	6 to 10
2.	Blue clay	12 to 14
3.	Quicksand and washed gravel.	

A well at Centerburg passed through—

		FEET.
1.	Yellow clay	12
2.	Blue clay	39

when water was obtained. The material below was not penetrated; no wells here are sunk to the rock.

The timber in this region is beach, maple, oak, white and black ash, and black walnut. Of the latter a very large amount of valuable timber has been cut for shipment east.

The small streams in Hilliar township form the head waters of Licking River. They are bordered with gently rolling hills of modified Drift, containing angular fragments of the Waverly and rounded granitic bowlders, and rising forty feet above the bed of the stream. The soil is a mixture of clay and sand, rich in the debris of the lime rocks.

The wells at Lock, on the south line of Milford, pass through eight to fifteen feet of yellow clay, and fifteen to twenty feet of blue clay, then on the higher lands striking gravel, on the lower, quicksand. The surface is of the same general character through Milford and Miller townships, viz., undulating hills from which the finer material of the Drift has been washed, bordering flood plains through which the small streams flow, generally over beds of water-rolled pebbles, this material resting upon unmodified drift. A section of the bank exposed by a bend in Licking Creek shows this arrangement of the materials:

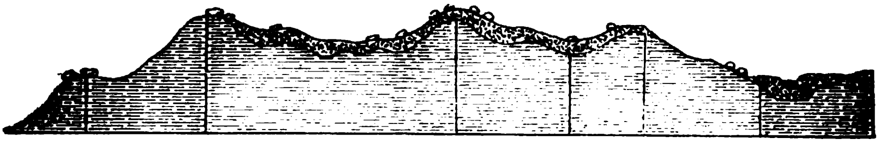
		FEET.
1.	Yellow clay and coarse unstratified gravel	4
2.	Water-washed sand and gravel, rudely stratified	8
3.	Yellow boulder clay	1 to 2
4.	Blue boulder clay to bottom	15

The whole mass is filled with rock debris, that of the two upper members nearly all rounded and water-worn. Granitic and limestone fragments occur in all.

Eastward from Lock, Drift apparently fills the old valley of erosion to the foot of the hills east of the Baltimore and Ohio Railroad. These hills rise somewhat abruptly to the height of three hundred feet above the valley. Their slopes are covered with Drift, so that no rock exposures are found until the descent into the valley of Owl Creek is reached, about one mile from Mt. Vernon. The rock is here broken and crushed as if by lateral thrust. An old water-plain borders the west side of the railroad from Mt. Vernon to the south line of the county, marked by successive terrraces, and from one to three miles wide. It is bordered by hills of modified Drift, and forms an extension northward of the valley in which Owl Creek flows, until deflected to the east by Mt. Vernon.

The following profile, reaching from Mt. Vernon to Martinsburg, omitting many of the less important hills and valleys, will show the character of the Drift deposits in this part of the county:

PROFILE SECTION FROM MT. VERNON TO MARTINSBURG.



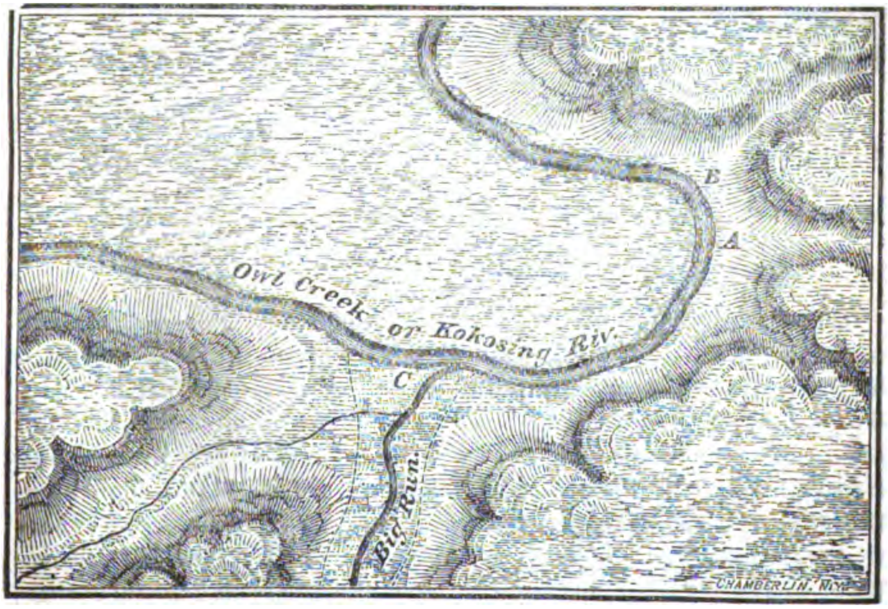
The slope of the first hill, which rises to one hundred and seventy feet above Mt. Vernon, exhibits the olive shales of the Waverly covered by Waverly debris, with no evidences of Drift except occasional granite bowlders. On the top of this hill are found thin bowlder clay and granitic pebbles. Ascending the next slope to the height of three hundred and ten feet, the outcrop and debris of the Waverly continues, with no Drift material until passing about twenty feet downward on the south-east side. There granite bowlders are found, and the slope below is covered with Drift mingled with angular fragments of the local rocks. The Drift continues to the top of the next hill, two hundred and eighty-five feet, but is thin, and the soil is composed mainly of local debris. One mile north of the last are broad expanses of gently undulating sandy fields, exhibiting no evidence of Drift except large scattered bowlders of granite, the soil like the banks of sandy streams. Rising above these sandy billows are irregular ridges of clay composed largely of foreign Drift. At the highest elevation—three hundred and five feet—the hill is capped with a heavy deposit of clay Drift. On the descending slope, at twenty feet from the top, a sandy water-washed surface is reached with granitic boulders scattered over it. Descending toward the eastern valley, the Drift on the slopes is deeper. On the last slope, at an elevation of two hundred and seventy-five feet, the Drift disappears, and the crushed layers of the Waverly are covered only with their own debris. At two hundred and fifteen feet the river Drift of washed sand, gravel, and granitic boulders is reached, which passes into the alluvium of the valley, cut by Big Run at an elevation of one hundred and sixty-five feet above Mt. Vernon. Ascending the divide on the opposite side of the stream, the same series of materials is found in reverse order, viz.:

1. **Alluvium of valley, bordered by river Drift.**
2. **Outcrops of Waverly covered by Waverly debris, and occasional large granite bowlders.**
3. **Heavy clay Drift.**
4. **At two hundred and twenty-five feet above Mt. Vernon, outcrop of Waverly without Drift, continuing up a gentle slope to two hundred and sixty feet, where there is a broad undulating plateau of water-washed sandy soil, with occasional Drift boulders.**
5. **At an elevation of two hundred and seventy-five feet, hills covered with Drift, which extends in the protected depressions to two hundred and thirty-five feet.**
6. **At three hundred feet, on the last elevation before descending into the valley at Martinsburg, Waverly debris without any appearance of Drift.**

In Jackson township the Wahatomaka Creek—which has the sources of most of its tributaries in the recently eroded ravines of the Coal Measure rocks on the east—falls a little north of Bladensburg into the old channel now occupied by Big Run, and is bordered by irregular sandy hills of water-washed material; which are continued northward to the junction of Big Run with Owl Creek.

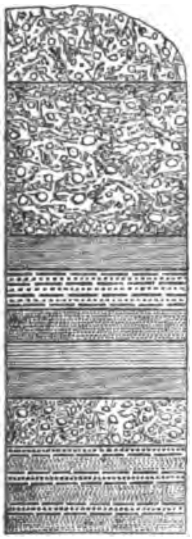
At Gambier the bend in Owl Creek or Kokosing River, called the horse-shoe, gives an interesting exposure of the Drift, and furnishes important facts touching the elevation of the surface deposits and drainage. The following is an outline:

THE HORSE-SHOE.



The river here flows through a broad valley of alluvium, containing pebbles, and resting upon a deep deposit of water-washed gravel. An old deeply excavated channel opens southward at C, the mouth of Big Run, now filled at the surface with sandy material. At A a narrow channel is filled with the original Drift, which has been carried away at the surface by recent erosion, but not down to the present water level. The encroachment of the river at this point exposes a clean section of this original deposit, as given below:

SECTION OF OLD VALLEY DRIFT, BIG RUN.



	FT.
Yellow clay, with Drift bowlders and pebbles, and many flat fragments of local rocks	8
Blue bowlder clay unstratified, with rounded granitic bowlders, gravel, and angular fragments of glacial rocks	20
Laminated blue clay	3
Coarse stratified gravel	4
Coarse stratified sand	2
Yellow laminated clay	2
Blue laminated clay	2
Unstratified bowlder clay	4
Stratified sand and gravel	8

At Mt. Vernon, wells sunk in the alluvium pass only through sand and gravel. Those on the sandy slopes strike—

		FT.
1.	Yellow clay	10 to 15
2.	Blue clay	30 to 40
3.	Gravel, sand, and broken stone to bed rock.	

That part of the county east of the Baltimore and Ohio Railroad and north of the Cleveland, Mt. Vernon and Columbus Railroad, consisted originally of a high undulating table land, covered with glacial Drift. Erosion has intersected it with narrow ravines, and filled it with small streams, leaving a succession of well-rounded hills of very graceful outline, characteristic of the Waverly in this part of the State. This peculiarity is only modified by outcrops of the Waverly Conglomerate. Where this is wanting, or is below the bottoms of the valleys, the hills are entirely without benches; the lines of the landscape are all graceful curves;

the hills susceptible of cultivation to the top, and presenting scenes of quiet beauty rarely excelled. These characteristics change upon approaching the Coal Measure rocks in the south-east and north-east parts of the county.

Standing near the line of division, the observer need make no mistake in regard to the character of any of the hills in sight; those which are symmetrically rounded to the top will be found composed wholly of the Waverly; those of which the summits show benches and irregular lines of contour are capped with the coal rocks. The debris of the olive shales, the upper members of the Waverly, here make a peculiarly elastic and excellent roadway, so that traveling in the night along the margin of the coal field the sound of the carriage wheels will enable one to say when he is passing over a road of this material. These hills at the north retain patches of undisturbed Drift on protected slopes, with scattered erratics, the latter sometimes very abundant on the lower slopes and in the beds of streams, where no other evidences of the Drift are preserved. These hills, when denuded of Drift, have but a slight covering of soil, the shales of the Waverly, finely broken up, coming near to the surface.

West of Ankenytown is a plain about ten miles wide, without rock exposures, but with occasional gravel ridges, the whole composed of river Drift, of sand, gravel and clay on the margin, resting on quicksand and gravel, the whole of unknown depth, filling up the old pre-glacial channel.

The surface deposits render the valley of Owl Creek and the broad plain west of the Baltimore and Ohio Railroad remarkably productive, and the crops rarely or never are injured by drought or rain. The rich alluvium, resting on a deep bed of gravel, through which the stream runs, is most thoroughly underdrained, and the soil can retain an excess of moisture only when the stream overflows its banks. The water also fills this gravel from bluff to bluff to the level of the stream, and the crops can suffer but little from drought, unless so protracted that the stream becomes dry. These surface deposits also afford materials for excellent roads. The drainage in the valleys is perfect, and the heavy beds of gravel which border them are every where available. Upon the hills the decomposed Waverly shales make a road-bed that is well nigh perfect, smooth, elastic, and well drained. Only among the hills, where the clay Drift has been protected and retained, is there a necessity of carrying material for road-making to any distance.

These peculiarities, with the graceful outlines of the hills, their variety and fertility, give great beauty to the county, and where put under thorough cultivation, will make it one of the most delightful spots in the State or country.

TIMBER.

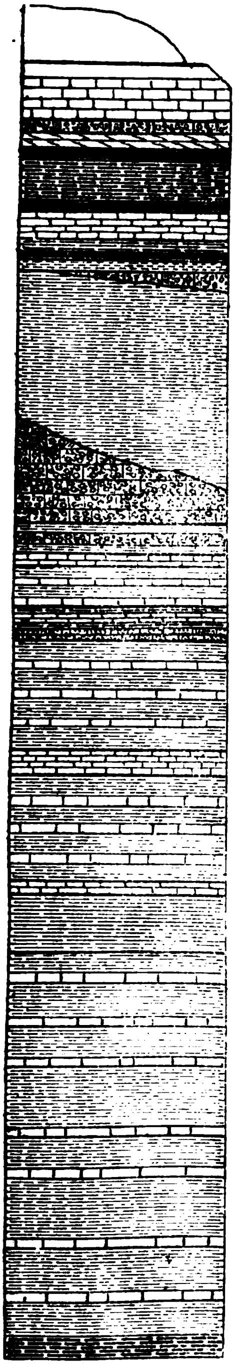
In the broad valleys of the streams the native timber was mainly hard maple and black walnut; of the latter a very large part was destroyed before its value was known, but very much has been cut and shipped to market. The large sugar maples in this district seemed a strange thing, but the thorough drainage afforded by the deep deposit of gravel fully explains their presence. If the alluvium rested upon clay, we should find soft maple, elm, and sycamore growing upon it, but no sugar maple. On the Waverly hills a mixed forest of maple, beech, hickory, oak, and pepperidge; in a few places on the borders of the stream hemlock, and on the ridges where the Waverly Conglomerate comes to the surface, chestnut. On the Coal Measure rocks the predominating timber is oak. On all the hills are scattered trees of whitewood, cucumber, black and white ash, and elm; the latter three being most abundant where the original glacial Drift remains.

GEOLOGICAL STRUCTURE.

The series of rocks exposed in the county comprise about two hundred and seventy-five feet of the Coal Measures, and about three hundred feet of the Upper Waverly, but borings for oil have extended our knowledge of the strata down to the Huron shale, and have afforded important information in regard to the character and thickness of the sub-carboniferous rocks.

The following is a general section of the rocks underlying Knox county, as made known by observations of rock exposures and by the borings for petroleum:

GENERAL SECTION OF THE ROCKS OF KNOX COUNTY.



	Ft.
Covered debris of cherty limestone	115
Bench and springs, coal horizon.	
Sandstone	40
Coarse conglomerate	½ to 1½
Irregularly bedded sandstone	3 to 4
Coal	1½ to 2
Black shale	45
Coal, outcrop, and fire-clay.	
Shaly sandstone	30
Black shale	10
Coal, outcrop, and fire-clay.	
Sandy shale	10
Conglomerate	0 to 15
Coal Measures	255 to 272
Olive shales of Waverly	200 to 250
Waverly Conglomerate	50 to 100
Waverly Conglomerate, with bands of argillaceous shale	30
Fine grained micaceous sandstone	1½
Argillaceous shales, with silicious bands	41½
Fine bluish sandstone, upper part with bands of shale, lower with quartz pebbles	22
Argillaceous shales, with silicious bands	125
Very fine blue sandstone, with argillaceous bands—local	20
Argillaceous shale. with hard blue silicious bands	115
Fine dark sandstone. lighter at bottom	8½
Red or chocolate shales, with blue argillaceous bands at bottom	62
	726
Blue argillaceous shales. with hard silicious bands—Erie	539
Huron shale.	
Total thickness of rocks exposed or penetrated	1527
Interval between coal-measures and Huron shales	1265

It will be seen from this section that the highest hills rise over two hundred and fifty feet above the Carboniferous Conglomerate. The coal-measure rocks cover the greater part of Jackson and Butler townships, and a small area in the north part of Jefferson. The highest hills in Jackson rise one hundred feet above the upper outcrops of rock and are covered with the bleached and earthy debris of cherty limestone. These limestone hills are exceedingly fertile, and produce excellent crops of corn and other grains. The upper rock exposed is a massive sand rock, probably the equivalent of the Massillon sandstone, and the upper coal bears a strong resemblance to Coal No. 1. Attempts have been made to mine it for local use, and the coal has been exposed of a thickness of from eighteen to twenty-four inches. The material immediately above it indicates the action of eroding agencies immediately after the deposition of the shales covering the coal.

The shale is in patches, sometimes three to four feet thick, in other places wanting; the sandstone there resting upon the coal, and in places cutting it out altogether. This sandstone is irregularly bedded with waved and contorted lines of stratification, and is capped with from sixteen to eighteen inches of coarse pudding stone or breccia, containing also water-worn quartz pebbles. The heavy sandstone above this is compact, massive, and evenly bedded.

The coal is of fair quality, in two benches, in places showing considerable sulphur, and at the outcrops does not exhibit a thickness which would make mining profitable except for local use. The thickness and extent of the coal rocks, and the fact that they include three horizons of coal, would fully justify further exploration. This exploration could be made most easily by drilling from the top of the hills, so that the holes would pierce all the strata, disclosing their character and thickness. The shales below this coal indicate less active disturbances, and whatever was originally deposited on the line of the two lower outcrops probably now remains. A fourth horizon of coal is found above the upper massive sandstone at the bench on the hills, one hundred feet below the highest points, but no outcrop of rocks was observed at this elevation. The cherty debris of the limestone above Coal No. 4 is abundant upon many of the hills, and constitutes flint ridges in the northern part of Butler township. Much less promising territory in other places has been successfully explored, and valuable deposits of coal found. The coal rocks of Butler township extend to within about eight and a half miles of Gambier. At the nearest point is an outcrop of the fire-clay of the lower coal, but the water flowing from it shows much sulphur, an indication of coal of inferior quality.

Patches of the Sub-carboniferous Conglomerate are found in place in most of the deep ravines of Butler and Jackson. The maximum thickness observed was fifteen feet. A small patch of the coal rocks caps some of the highest hills in the north part of Jefferson township, and extends into Ashland county, where coal is found. This coal extends into Knox county, and thin coal seams are found near the tops of the hills. Some of them have been explored and abandoned, as if furnishing no valuable coal. They are probably of no value.

Olive Shales.—The olive shales of the Waverly immediately underlie the Coal Conglomerate, and reach a maximum thickness of two hundred and fifty feet. They are composed of thin, evenly-bedded, silicious rock, of a yellow olive color, the layers occasionally of sufficient thickness to afford a fair building stone. The general homogeneous character of this member of the Waverly series gives a graceful outline to the hills, leaving no benches as the result of irregular erosion of alternations of hard and soft rock strata; the debris, when not covered with Drift, giving a light, porous soil, and, where of sufficient depth, quite productive. The porous nature of the soil and the abundance of small rock fragments in it causes it to absorb the rainfall and prevent the beauty of the slopes from being marred by gullies or irregular erosion. The ordinary shells and fucoids of the Waverly are disclosed here and there in these shales, but nothing of special interest was discovered in the way of fossils.

The Waverly Conglomerate.—This is continued from Richland south through the eastern part of Knox county, presenting the best exposure along the banks of Owl Creek near the line between Butler and Union townships. It apparently forms here the crest of an anticlinal, and dips to the east at an angle of about 25°. Further eastward is apparently another anticlinal, the rock dipping in opposite directions. The real character of these disturbances is doubtful. The massive Conglomerate is much broken, and borders the stream of which the old channel is known to be something like one hundred feet below the present bed. It is quite possible that all the displacement is covered by the partial undermining of the Waverly Conglomerate, the ancient cañon cutting below it and eroding the softer shales beneath, so that this heavy sandrock has settled down, and this, instead of an upheaval, has curved the anticlinals. If we knew that this coarse, massive rock extended westward through the county, then we might be certain that the appearance at this point was the result of deep-rooted disturbances, for the general dip of the strata is eastwardly, and the rock so boldly exposed about Millwood does not appear in the western parts of the county, where it ought to rise toward the top of the hills. But here in Richland county this Conglomerate forms a comparatively narrow, tortuous belt, apparently marking an old shore line. The following noted exposures of the Waverly illustrate this fact. Ascending the hills on the road from Mt. Vernon towards Martinsburg, the broken outcrop of the Waverly may be seen on a level with the railroad, and may be found at all elevations on the slopes of the hills to the height of three hundred feet. Throughout this thickness it consists of thin layers constituting the ordinary olive shales. The same thing is seen in ascending the hills between Mt. Vernon and Amity. If the Waverly Conglomerate extends to this part of the county it must dip to the west below the valleys; and in that case the hills would all be capped by the Coal Measure rocks. They are, however, Waverly to the top. From thirty to forty feet of this Conglomerate is exposed in the bluffs of the new channel of Owl Creek, below Millwood, the top being ninety-five feet below Gambier. Three-fourths of a mile south-west of Brownsville the top of the Conglomerate is fifty-five feet above Gambier. It is here full of pebbles, and contains much iron. At Brownsville the Waverly is quarried, and furnishes hard, coarse rock, full of pebbles, but more fissile than the ordinary Conglomerate. The stream west of Brownsville, at an elevation of five feet above Gambier, cuts through the Waverly Conglomerate, which rises to an elevation in the hills not easily determined; the general level of the surface west is two hundred and forty-five feet above this stream. East of North Liberty the top of the highest hills is capped with a coarse, cherty Conglomerate, containing much iron, the base of which is two hundred and forty-five feet above the Waverly Conglomerate, near Brownsville. This is an outlying mass of the true Carboniferous Conglomerate, with the olive shales below it. The descent from the base of this rock to Frederick is two hundred and eighty feet. Here Owl Creek has cut a new channel through a spur of the Waverly, but the Waverly Conglomerate is not exposed, nor is it on the western slope from North Liberty. At A. K. Folb's quarry, in Monroe township, one and a half miles north-east of Gambier, and forty feet below it, the Waverly affords large quantities of good stone, though much stripping is required. Many of the layers are thin and much broken. The heaviest layers are about three feet thick, all fine-grained, most of them yellow, but some blue, with a sharp grit, and resembling the Berea. The ordinary shells and crinoids of the Waverly are here abundant. At Critchfield's quarry, Howard township, about two miles east of Howard station, and fifty feet below, a face of twenty feet of the rock is exposed, much of it in thick layers, coarse, with some pebbles, faintly colored like the Mansfield rock, but generally yellow. This is the horizon of the Waverly Conglomerate, and is by barometer ninety feet below Gambier. Near Brownsville, it fifty-five feet, and south, at Millwood, ninety-five feet below Gambier. These facts indicate a pretty uniform dip of this rock to the south-east, and that it is a continuation of the coarse body of rock in the east part of Richland county. On the C., Mt. V. & C. Railroad, half a mile east of Howard station, a quarry belonging to Hurd & Israel has been opened, at an elevation fifty feet below Critchfield's, of which the following is a section so far as exposed:

	FEET.
1. Shaly limestone with layers of argillaceous shale	20
2. Massive sandstone	6 to 8

The lower stratum is a coarse stone with much iron, containing pockets of soft iron ore, in some places striped like the Mansfield stone, and in others of a deep cherry red; general color yellow; fucoids the only fossils observed.

Indian Field Run, a small stream emptying into Owl Creek from Harrison township, and occupying a rocky valley of recent erosion, gives fine exposures of the Waverly, where many of the layers are from three to four feet thick, but they contain many concretions or pockets of iron ore, and occasionally nodules of iron pyrites. Impressions of fucoids are here abundant. The general color of the rock is yellow. The valley and slopes are filled with the debris of the local rocks, with no indications of Drift except an occasional granitic bowlder. Near the top of the hill on the west, Drift bowlders are more abundant, and heavy masses of Drift cover the western slope descending toward Owl Creek.

From thirty to forty feet of the bottom of the Waverly Conglomerate has argillaceous bands interstratified with the quartz-bearing beds of sandstone. Below this the mass of the material to the chocolate shales is argillaceous, with frequent hard bands of calcareo-silicious rock, and occasionally strata of sandstone. One of the latter, No. 19 of the general section, is twenty-two feet thick, the upper part with argillaceous bands, the lower carrying quartz pebbles; another stratum, No. 21, one hundred and twenty-five feet below the last, is a very fine blue compact sandstone, bearing some resemblance to the finer grades of the Berea. It is not persistent, and in most of the hills its horizon is occupied by argillaceous shales. Indeed, all these thin beds of sandstone seem to disappear eastward, the whole interval between the Waverly Conglomerate and the chocolate shale being filled with argillaceous shale.

One hundred and fifteen feet below the hard blue sandstone mentioned above, a similar rock occurs eight and a half feet thick, the upper part dark colored. This is about on the horizon of the Berea grit, and it is evident that the latter, which is a conspicuous and well marked deposit in all the northeastern counties of the State, thins out in this direction, and like the Carboniferous Conglomerate, it was a shore deposit, the coarse materials being carried no great distance into the deep waters which then lay to the south. At the depth of about six hundred and seventy feet below the Sub-carboniferous conglomerate is the red or chocolate shale, the lowest member of the Waverly, and the first in this county which can be identified fully with any of the subdivisions that are so clearly defined in the valley of the Cuyahoga. This is apparently the equivalent of the Bedford shale, which in many places at the north is all or in part red shale. In Erie county this red shale reaches a thickness of some forty feet. The well-borings here show that it is very homogeneous in structure, except that near the bottom there are interstratified bands of argillaceous shale.

Below this chocolate shale are the Erie shales, which so far as their character can be determined by an inspection of the borings, present precisely the same characteristics as in the northwestern counties, where they are fully exposed. They consist of a mass of soft, blue argillaceous shale, with hard calcareo-silicious bands.

Below this Erie lies the Huron or "Black shale," the thickness of which cannot be determined. It seems evident that along the western margin of the Sub-carboniferous rocks the lower members of this series and the upper member of the Devonian are thinning out, and that their advance further west is not altogether the result of erosion, but that their extent in that direction was limited by the presence of dry land at the time of their deposit.

Petroleum and Gas.—The report upon this county would be incomplete without an acknowledgment of the very important aid derived from the borings for oil on Owl Creek, and a brief account of this interesting work. Some ten years ago the attention of enterprising parties was called to the "oil signs" of the eastern part of Knox county. On the western margin of the coal field were indications of dislocation in the rock strata; gas springs were abundant, and from several places it is reported that oil in small quantities was obtained. A company was organized, territory leased, and since that time something like $85,000 has been expended in explorations, mainly under the superintendence of Peter Neff, Esq., of Gambier. The registers of the wells, which have been kept with commendable care by Mr. Neff, show that there is a marked disturbance in the strata extending to the lower rocks reached, its apparent extent, however, being exaggerated by the causes mentioned on a preceding page.

The red or chocolate shales, the lower member of the Sub-carboniferous, constitute a well marked horizon, and enable us to determine the relative position of the different strata in the wells which reach this material.

The location of eight wells is indicated on the accompanying map of the territory around the junction of the Kokosing and Mohican rivers, and the following table gives the depth below the surface of the top of the red shale:

	Ft.
Well No. 1	615
" 2	615
" 3	591
" 4	562 (?)
" 5	705
" 6	675
" 7	607
" 8	627

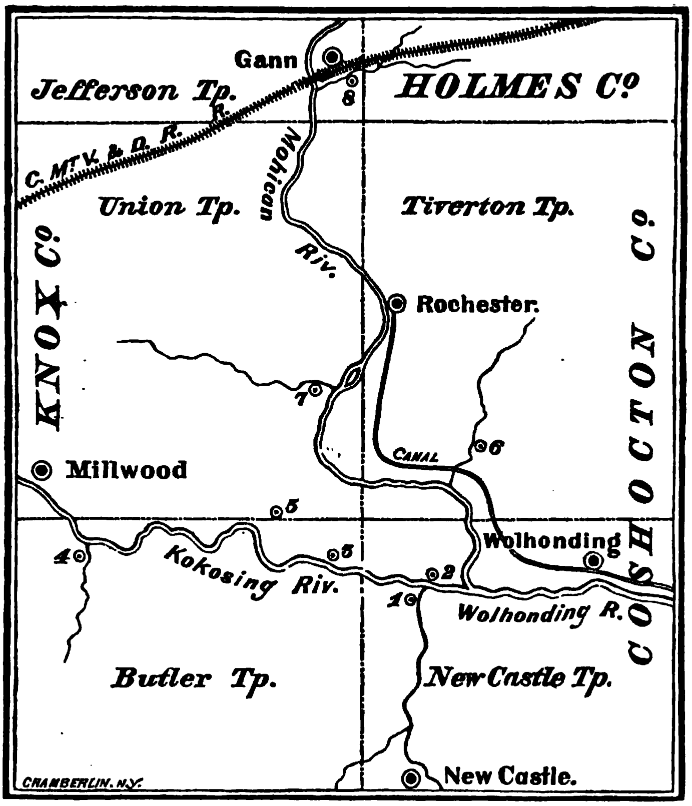
By barometrical observations taken as rapidly as practicable, and on a clear day, the elevation of the surface at each of the wells above that of Nos. 1 and 2, is as follows:

	Ft.
No. 3	50
" 4	125
" 5	95
" 6	75
" 7	25
" 8	30

From these data, the dip of the upper surface of the red shale between the different wells, is as follows:

	Ft.
From No. 8 to Nos. 1 and 2	18
" No. 8 to No. 6	33
" No. 4 to Nos. 1 and 2	128 (?)
" No. 5 to Nos. 1 and 2	135
" No. 5 to No. 6	150
" No. 3 to Nos. 1 and 2	74
" No. 7 to No. 6	48
" Nos. 1 and 2 to No. 6	15
" No. 4 to No. 8	160 (?)
" No. 7 to No. 2	33
" No. 7 to No. 8	15
" No. 3 to No. 8	56
" No. 3 to No. 7	41
" No. 3 to No. 6	189

Map of Kokosing Oil District.



The record of No. 4 is not entirely reliable, and some uncertainty exists as to the depth at which the red shale was then struck, but all the other borings indicate a dip to the north-east, and that the line joining No. 8 and No. 2 is nearly on the line of the strike.

The following is a copy of the register of No. 1, on the south side of the Kokosing, three hundred feet west of its junction with the Mohican, supplemented at the bottom by the register of No. 2, five hundred feet north of it, and on the opposite side of the stream.

Specimens of the borings bearing the number on the right-hand column are deposited in the State Cabinet, at Columbus:

No. of Strata.	Material.	Thickness.	Depth.	No. of Sample.
1.	Earth	10	..	..
2.	Coarse yellow sand-rock	7	17	1
3.	Fine sand-rock	2	19	2
4.	Drab "	3	22	3
5.	Coarse "	1	23	4

No. of Strata.	Material.	Thickness.	Depth.	No. of Sample.
6.	Coarse sand-rock	10	33	6 to 13
7.	“ “	3	36	13
8.	Drab “	6	42	14 to 17
9.	“ “ fine	2	44	18
10.	Lighter “	1	45	19
11.	Coarse “	2	47	20
12.	“ “	2	49	21
13.	“ “	2	51	22
14.	“ “	2	53	23
15.	“ “	2	55	24
16.	Fine, hard, blue sandstone	9	64	25
17.	“ “ lighter sandstone	2	66	26
18.	“ “ sandstone, with pyrites	2	68	26½
19.	Coarse blue sandstone	8	76	27
20.	Fine blue sandstone, with shale partings	14	90	28
21.	“ “ “ “	8	98	29
22.	Bluish gray shale	20	118	30
23.	Silicious blue shale	4	122	31
24.	Blue shale	8	130	32
25.	Hard, fine sandstone	12	142	33
26.	Blue argillaceous shale	10	152	34
27.	“ “ lighter	12	164	35
28.	Fine, hard sandstone, with pyrites	4	168	36
29.	Fine, blue sandstone	8	176	37
30.	“ “ with shale bands	10	186	38
31.	Fine-grained micaceous sandstone	16	202	39
32.	Blue argillaceous shale, with sandy bands	12	214	40
33.	“ “ “ “	18	232	41
34.	“ “ “ “	18	250	42
35.	Argillaceous shale	8	258	43
36.	Blue grit sandstone	6	264	44
37.	“ “ shale bands	12	276	45
38.	Dark, bluish shale	4	280	46
39.	“ “ with thin silicious bands	20	300	47 and 48
40.	“ “ “ “	10	310	49
41.	“ “ “ “	18	328	50
42.	“ “ “ “	34	362	51
43.	“ “ “ “	2	364	52
44.	Dark, bluish shale, with red ferruginous and silicious bands	36	400	53
45.	Red sandstone and blue shale in bands	64	464	54
46.	“ more silicious	36	500	55
47.	Blue argillaceous shale	20	520	56
48.	“ “ with dark sandstone bands	24	544	57
49.	Dark shale	24	568	58
50.	“ lighter	14	582	59
51.	“	16	598	60

No. of Strata.	Material.	Thickness.	Depth.	No. of Sample.
52.	Sand-rock	..	...	61
53.	"	15	613	2-62
54.	Red shale	12	625	2-63
	Total depth	625		

In all the wells bored, a similar succession of strata has been pierced· The chocolate, the Erie, and the Huron shales were struck in all wells carried deep enough. The rocks included between these and the Coal Measures present alternations of sand-rock, argillaceous and sandy shales, which, after passing the olive shales that cap the Waverly, present a great variety in the different wells, and forbid all minute systematic subdivision. The most marked and most general alternations are exhibin the general section of the rocks of the county.

In nearly all the wells bored, gas, oil, and brine have been found in greater or less quantities, and from two of them a remarkably strong flow of gas has issued, which, properly utilized, can be made of great value.

The employment of natural gas elsewhere in the manufacture of iron would indicate the proper use to be made of it were it not that the wells are situated several miles from any railroad or other adequate means of transportation.

The Neff Petroleum Company, which, under the management of Peter Neff, of Gambier, made the explorations for oil, has been recently reorganized under the name of "The Kokosing Oil Company," and has attempted to utilize the gas in a novel manner, which gives promise of complete success. It has expended about $25,000 in erecting buildings and appliances for the manufacture of carbon-black, and is now obtaining a product not excelled in quality by any thing in the market, except bone or ivory-black, and has demonstrated that the well has a capacity of producing about five hundred pounds per day of No. 1 black, which is said to command, at wholesale, eighty cents per pound. This company has also devised a mode of utilizing the acid-waste of oil refineries, as it makes a very excellent carbon-black from that of ordinary quality, by using with the acid-waste a small amount of the natural gas. With eighteen hundred burners, for the consumption of the natural gas, it produces from forty to fifty pounds of the "Diamond," or No. 1 black, per day, and with twenty-eight burners, for the consumption of the acid-waste, one hundred to one hundred and fifty pounds per day of the "Pearl," or No. 2 black. The fact that the gas has flowed from the well without diminution for ten years gives good promise of its permanency; and the indications now are that by this use of the gas a good return will be secured to the stockholders for all the money so perseveringly expended in sinking the well.

Well No. 2 also yields a steady flow of gas, and from well No. 1 over three thousand barrels of water escape per day.

These wells afford an opportunity of obtaining exact measurements of the thickness of the Waverly rocks on the margin of the Coal Measures, and aid in determining the character of the successive strata.

Well No. 8, near Genoa Station, in Jefferson township, shows that the Waverly above the red shale is eight hundred and seventy-two feet in thickness, and, including the red shale, is nine hundred and thirty four feet, the Waverly being here capped with sixty feet of coarse sand-rock, either the Carboniferous Conglomerate or the Massillon sandstone. If this is regarded as the Conglomerate, sixty feet should be added to both the above numbers. Above the sand-rock is sixty feet of shaly sandstone, capped with the cherty limestone, underlain by fire-clay, and a faint outcrop of coal. I am inclined to regard this, as well as the massive sandstone over the lower coal at Newcastle, as the Massillon sandstone, Coals Nos. 1 and No. 2 having disappeared in this direction. The Massillon sandstone rests upon the Waverly, on the hills above Genoa Station, and directly on Coal No. 1, at Newcastle. At wells Nos. 1 and 2 the Waverly is eight hundred and seventy-seven feet thick, the olive shales rising to the coal, under the same rock, at Newcastle. Westward from that point this sandstone rests directly upon the Waverly shales.

At well No. 6, the interval between the lowest known coal, which is certainly near the base of the Coal Measures, and the top of the red shale, is eight hundred and fifty feet. This well commenced in the Waverly at one hundred and fifty-five feet below the lowest coal, passed through Waverly shales to the depth of two hundred and forty feet, then argillaceous shales, with not more than six thin silicious bands, four hundred and fifty-eight feet. At six hundred and ninety-eight feet a hard, fine-grained sand-rock, with oil, was met with, but it was without crevices, and no water flowed from it. The entire absence of the Waverly Conglomerate, and of the second sand-rock, and the predominance of argillaceous shale is quite significant. Westward, the materials in all the wells gradually become coarser; the Waverly Conglomerate, and the other sand-rocks were found in normal position, and the supply of oil in the wells was more abundant. All the indications point to an old shore line, a little to the west during the deposit of the Waverly rocks, along which the coarse sandstones accumulated as shore deposits, while the finer argillaceous shales were deposited in deep water at the east.

In well No. 3 the second sand-rock was struck at two hundred and eighty-five feet, and was six feet deep; the third sand-rock at five hundred and eighty-five feet, and was nine feet thick. The red shale was reached at five hundred and ninety-five feet. This well still flows oil, gas and brine; the latter yielding two pounds and ten ounces of salt from eleven quarts of water.

Well No. 4, the "Buckingham Well," yields heavy green oil from the thin sand-rock, which was struck at about five hundred and sixty feet, and is eighty-eight feet thick. The record of this well was imperfectly kept, and the red shale was not certainly located. Mr. Neff, in a supplemental report, puts it at six hundred and twenty-eight feet. If this is correct, there is a reverse dip here to the south-west from well No. 5 to well No. 4, of twenty-eight feet.

In well No. 5, the "Hard Well," the third sand-rock was struck at five hundred and seventy-five feet, and was ten feet thick, yielding gas, oil, and water, which still flow from the top of the tube, about eight gallons of oil per day. The red shale was reached at five hundred and eighty feet. If the record of the well is correct, the interval between the top of the red shale and the top of the Huron is sixty-two feet less than at well No. 8 or No. 6.

These borings develop the following interesting facts:

The surface disturbance is much in excess of that of the deeply buried strata, is therefore in part superficial, and covered by the undermining of the surface, as suggested above.

There is a deep seated disturbance involving all the rocks down to and including the Huron shale, which is the great oil-producing rock, so that the dip of the strata is substantially northeast. Eastward the silicious rocks gradually give place to argillaceous shales, the coarse sandstones becoming thin or disappearing altogether. In the opposite direction, or westward, the materials are coarser, and the sand-rocks thicker.

On the eastern margin of the territory explored by boring, gas predominates, and at well No. 2 has flowed for ten years with a continuous pressure of about one hundred and eighty pounds to the inch. Westward, petroleum is more abundant. The oil is thus far nearly all found in the sand-rock directly above the red shales.

The water obtained *above* the second sand-rock and that below the red shale is fresh; that between the second sand-rock and the red shale is salt, and affords a suggestion as to the probable source of the coloring material in the red shale—iron deposited by the salt water.

The results obtained suggest further explorations in the south-eastern part of the district for gas, and in the western part for oil. With the new uses developed for natural gas, it is difficult to decide which would be the more valuable.

Recent borings for salt north of Shawnee, in Perry county, reach the red shale at a depth of eight hundred and thirty feet, commencing on the horizon of the blue limestone, which is here one hundred and thirty-five feet below Coal No. 6, or the Great Vein of Perry county. The red shale is reported as from thirty to forty feet thick, and is here also at the base of the salt-bearing strata.

ANALYSIS OF GAS FROM WELLS.

An analysis made by Prof. Edw. W. Morley, of the gas emitted by one of Mr. Neff's gas wells, and such as is used by him for the manufacture of lampblack, gave the following formula for its composition:

Specific gravity		0.65
Oxygen		0.8
Carbonic acid		0.3
" oxide		0.5
Carbon and hydrogen, equivalent to	Marsh gas	81.4
	Ethyl hydride	12.2
Nitrogen		4.8
		100.0

ADDENDA.

In well No. 8, at about 930 feet, and in the Erie shales, below the characteristic Red Shale, was found a Sand Rock about four feet thick, and saturated with Petroleum. In Well No. 7, at about 915 feet, was found this Sand Rock below the Red Shale, and about 15 feet thick; the drill passed through it without encountering a seam or crevice, but found this rock fully saturated with oil; while, in same Well No. 7, the Sand Rock lying immediately upon the Red Shale, this being the Oil horizon, was found to be about six feet thick without open seams, and little oil.

There is an absence of gas in Wells Nos. 6, 7 and 8. In Well No. 6 the Sand Rock immediately upon the Red Shale was about 18 inches thick. This well should be drilled about 300 feet deeper to test for the Sand Rock found below the Red Shale in Wells Nos. 7 and 8. It appears that the Sand Rocks are deposited in lens forms. On page 20, the 12th line from bottom—it is now proven that the estimated product of the carbon was too great, and should be about 140 pounds; while the gas of the several wells would produce the full amount of carbon estimated. This report on Knox County, Ohio, was written in the year 1876. This addenda was submitted to and approved by Prof. M. C. Read.

MAY, 1878.

PETROLEUM.

For some interesting details of the progress and history of developments for oil; the description of Neff Well No. 1, famous for its gas and spouting water, bored in 1865; the casing out of all water above the Red Shale; the drilling of dry holes; the dispensing with "seed-bags" in pumping by use of a cap on top of casing-pipe, 1866; torpedoes, etc., by Peter Neff—see the

"PROSPECTUS
OF THE
NEFF PETROLEUM COMPANY,
WITH THE
GEOLOGICAL REPORTS
OF
Prof. A. WINCHELL,
Prof. J. S. NEWBERRY,
Prof. H. L. SMITH.
TOGETHER WITH
OTHER ARTICLES OF INTEREST,
AND A
Map of Knox and Adjoining Counties, State of Ohio.
JUNE, 1866.
PRINTED BY THE WESTERN EPISCOPALIAN BOOK AND JOB OFFICE, GAMBIER, OHIO, 1866."

The Neff Petroleum Company was dissolved and this oil enterprise was re-organized in the corporation, under the Laws of Ohio in 1874, of the

KOKOSING OIL COMPANY.

The Directors are :

GAZZAM GANO, ESQ., President and Treasurer,
JAS. R. MURDOCH, ESQ., Secretary,
GEORGE K. SHOENBERGER, ESQ.,
JOHN SHILLITO, ESQ.,
Hon. GEORGE H. HILL,
} Cincinnati, Ohio.

With Branch Office at Gambier, Knox County, Ohio.

MAY, 1878.

PETROLEUM TERRITORY OF

THE KOKOSING OIL COMPANY.

We have, here in this county, the geological and physical duplicate of the Venango County (Pennsylvania) Oil Region, in its surface elevations and substratification formations. The hill-tops are about 750 feet above Lake Erie, and about 1100 feet above the ocean, while the streams are about 300 feet above Lake Erie. The anticlinals define a well-marked basin, in which the disturbances of the rocks are very great, and embrace the lowest formations, and result from being the western folds of the Allegheny Mountains. Deep down under this territory is the immense deposit of the Huron Shales, which constitute the source and laboratory of the gas and oil, which are found in Nature's store-house, provided in the disturbed and fissured sand-rock overlying the Red Shale, and immediately under the great argillaceous shales (soap-stones) which, as a sealing-wax, hold down the gas and oil in their store-house till tapped by the drill, to be released with terrific force.

The existence of gas, as is fully proven by developments, invariably predetermines the nearness of Petroleum, and, as a general rule, in the same horizon, but in parallel belts.

It is therefore a justifiable conclusion that this region embraces an oil territory of great richness, and should be sought for by boring wells.

Any well, judiciously located, is likely now to prove a success in producing oil. The risk here in testing is not much greater than it is "wild-catting" in the neighborhood of oil-producing territory.

The Black Works, and Gas Wells Nos. 1 and 2, are the property of

PETER NEFF,
Gambier, Knox County, Ohio.

MAY, 1878.

TRADE MARKS.

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Diploma and Medal.

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AWARDED BY UNITED STATES CENTENNIAL COMMISSION

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